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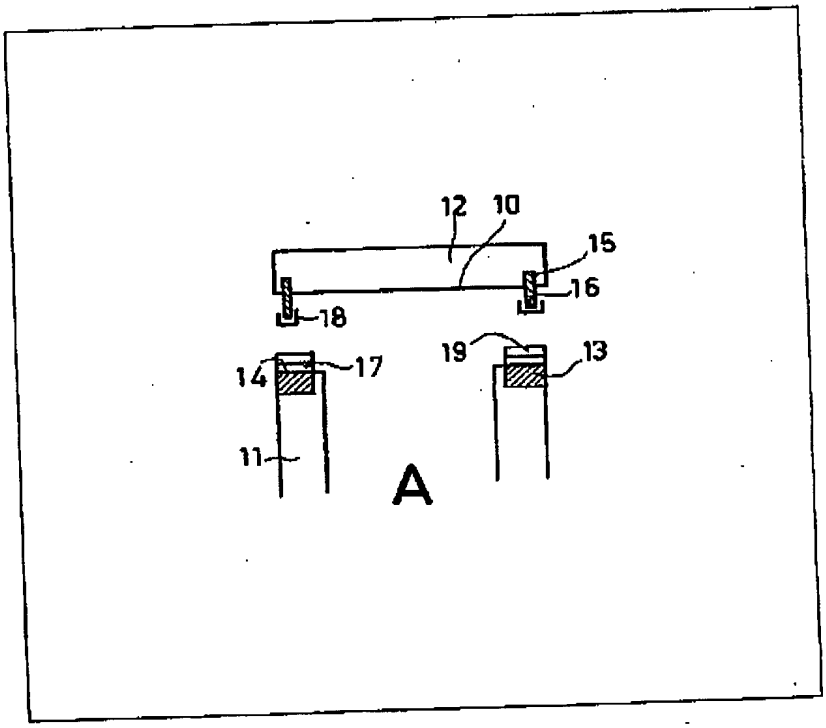
(71) Applicants
N.V. Philips'
Gloeilampenfabrieken,
Emmasingel 29,
Eindhoven,
The Netherlands.
(72) Inventors
Pierre Dolizy,
Bertrand Souque.
(74) Agents
R.J. Boxall

(54) **Electron tube**

(57) One bonding surface between the – e.g. glass – end plate 12 and tubular wall 11 of a discharge tube is formed by the end wall 16 – of at most 0.4 mm wall width – of a hollow metal cylinder 15, while the other bonding surface 14 is flat and wider than 0.4 mm, the two surfaces being hermetically bonded together by a cold pressure bond formed of a cold deformable metal, the specified dimensions ensuring that the pressure required for the bond is only a few kg per cm of length of bond. Members 13 and 15 may be of an iron-nickel-cobalt alloy with gold, copper, or silver coatings 17 and 18, the cold deformable metal 19 being indium, tin, or lead.



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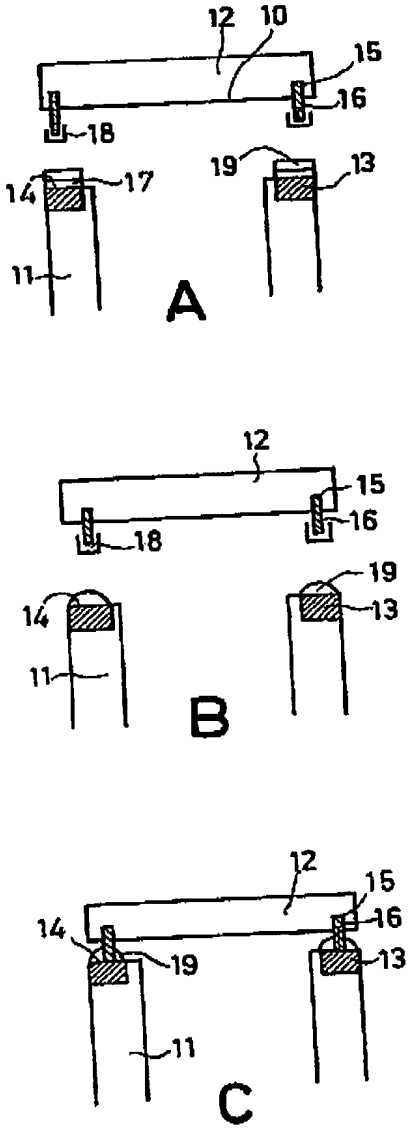

Fig.1

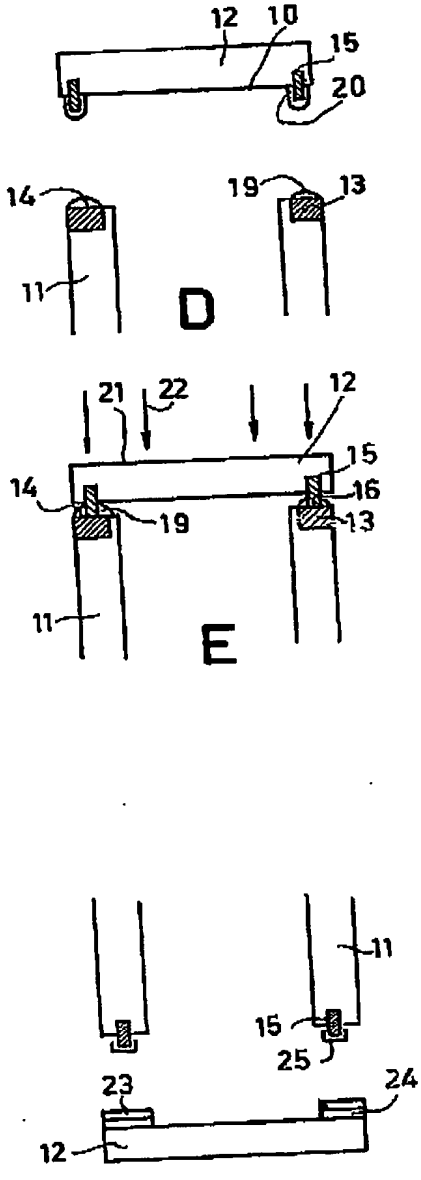

Fig.2

SPECIFICATION

Electron tube

The invention relates to an electron tube having an envelope composed of at least two parts, which parts having facing bonding surfaces bonded together hermetically by means of a pressure seal consisting of a cold deformable metal, and in which at least one of the bonding surfaces is formed by an end face of a hollow-cylindrical metal body connected to one of the envelope portions.

Such an electron tube is disclosed in British Patent Specification 1,143,535. The tube in this Specification is a tube the envelope of which comprises a first portion having a metal cylinder with a V-shaped groove, and a second portion having a metal cylinder with a V-shaped rim fitting in said groove. The V-shaped groove has a cold deformable metal, for example, indium, tin or lead. The hermetic seal of these portions is produced by pressing the V-shaped rim in the V-shaped groove. Measured in the circumferential direction of the seal a force in the order of magnitude of 10 kg/mm is necessary for this purpose. However, such large forces are objectionable when glass envelope portions are concerned in producing the bond because the said glass portions are easily damaged under the influence of these forces. For producing a reliable bond it is necessary to thoroughly clean previously the surfaces to be bonded. However, removing contaminations from a V-shaped groove without any residues remaining, has proved to be a very difficult job in practice.

Furthermore, for practical reasons, this construction is restricted to circular bonding surfaces.

It is the object of the invention to provide an improved construction for hermetically sealing envelope portions of an electron tube by means of a cold pressure bond, in which the surfaces to be bonded can easily be cleaned and the pressure force necessary for the pressure bond is very small.

For that purpose, according to the invention, an electron tube having an envelope composed of at least two parts, which parts have facing bonding surfaces bonded together hermetically by means of a pressure seal consisting of a cold deformable metal, and in which at least one of the bonding surfaces is formed by an end face of a hollow-cylindrical metal body connected to one of the envelope portions is characterized in that the bonding surface formed by the said end face on its circumference has a width of at most 0.4 mm and the other bonding surface facing the end face is substantially flat and on its circumference has a width of more than 0.4 mm.

For producing the pressure bond, only a small pressure force is necessary of a few kg per cm of length measured along the circumference of the bond. This makes the invention extremely suitable for use in photoelectric tubes in which the envelope portions are formed by a window having a radiation-sensitive layer and a tubular envelope portion.

Due to the temperature sensitivity of the radiation-sensitive layer, it is desirable to produce the pressure bond at a low temperature, for example, room temperature. On the other hand, the pressure forces for producing the pressure bond should be as small as possible so as not to damage the envelope portions of the tube.

Suitable sealing materials are, for example, tin, indium, lead or an alloy such as tin-lead, indium-tin and indium-bismuth.

An embodiment of a photoelectric tube according to the invention is characterized in that both the window and the tubular envelope portion have a hollow-cylindrical metal body, facing end faces of the bodies being bonded together by means of a pressure seal, the body having the narrower bonding surface being provided in the window. The hollow-cylindrical bodies preferably consist of alloys of iron, nickel and cobalt, the coefficient of expansion is substantially equal to that of the material of the - for example, glass - envelope portions of the tube.

Another embodiment of a photoelectric tube according to the invention is characterized in that the hollow-cylindrical metal body whose bonding surface has a width of at most 0.4 mm is provided in the tubular envelope portion and the facing bonding surface of the window consists of a layer of metal provided on the window.

The layer of metal provided on the bonding surface of the window serves as an adhesive layer for the sealing material. These adhesive layers which may also be provided on the bonding surfaces of the hollow-cylindrical metal bodies consist, for example, of nickel-chromium, nickel and gold or copper or silver. When the window consists of magnesium fluoride, calcium fluoride or lithium fluoride, the adhesive layer preferably consists of successively tantalum oxide, nickel-chromium, nickel and gold or copper or silver.

The invention will now be described in greater detail, by way of example, with reference to a drawing, in which:

Figure 1 shows, for a first embodiment of the invention, a number of phases A to E for producing a hermetic seal between a window and a tubular envelope portion of a photoelectric tube, and

Figure 2 shows another embodiment of the invention.

In Figure 1 the steps of sealing together a body of an electron tube and a window are shown successively at A, B, C, D and E. In all the elevations, A, B, C, D and E the body of the tube and the said window are shown in section and are denoted by 11 and 12, respectively. For the manufacture of this bond the tube body comprises at its end face circumferentially a metal part having a cross-section 13 which has a flat surface 14. The window 12 has a thin-walled metal cylinder 15 which is perpendicular to the faces of the window. The end of the cylinder outside the window is denoted by 16. These metal parts 13, 15 are sealed in the tube body

11 and in the window 12, respectively. Assuming that said window and said tube body consist of glass for industrial purposes, said seals are obtained, for example, upon pressing said body and said window, the glass being heated at a temperature exceeding the melting point of the glass. The thickness of the end 16 of the cylinder 15 is small as compared with the width of the surface 14. Said thickness is, for example, 0.2 mm while the width of the surface 14 is 1 to 2 mm. During stage A, end portion 16 and surface 14 are subjected to a surface treatment consisting of an etching and polishing treatment so as to make them flat, after which a cleaning and again an etching treatment are carried out. They are then coated with adhering layers of a metal which must easily migrate in the surfaces of parts 15 and 13 and at a later stage also in the sealing metal forming the tight pressure bond. According to an embodiment of the invention the cylinder 15 and the part having the cross-section 13 consist of an alloy known as "Dilver P", the sealing material consists of indium and the metal layers consist of gold. The gold layers deposited on surface 14 and end portion 16 are denoted by 17 and 18, respectively. The tube body 11 and the window 12 are arranged above each other in such manner that the end portion 16 and the surface 14 are situated in oppositely located horizontal planes. At ambient temperature an indium ring 19 is provided on the layer of gold 17. During stage B of the process the assembly is heated under vacuum to a temperature exceeding the melting temperature of indium, for example 300°C. The indium ring 19 expands over the surface 14 and then assumes the convex shape shown in stage B. During the stage C the window 12 approaches the tube body 11 until the end portion 16 of the cylinder 15 which is provided with the layer of gold 18 is dipped in the molten indium ring 19. During the stage D the window and the tube body are separated from each other. When the contact between 19 and 16 is interrupted, an indium layer 20 remains on end portion 16. The assembly is then allowed to cool to ambient temperature. During the stage E the window 12 and the tube body 11 are again moved towards each other in such manner that the indium ring 19 and the end portion 16 having an indium layer are contacted. While the tube body 11 is fixed, for example, by holding means not shown, a pressure is exerted on the surface 21 of the window 12 in the direction of the arrows 22. The end portion 16 of the cylinder 15 which is provided with the indium layer 20 again returns in the ring 19 so that a tight pressure seal is obtained, the exerted pressure being small due to the small thickness of the end portion 16 and corresponding to an exerted force of less than 0.3 kg per mm of length of the joint.

In this embodiment the interconnected metal parts 13 and 15 consist of iron-nickel-cobalt alloy (Fe-Ni-Co) such as the alloys known as "Dilver P", "Kovar", "Vacon", while the sealing material consists of indium, and the adhering layers on the Fe-Ni-Co parts which must adhere to iridium consist of gold. It will be obvious that the invention is not restricted to a pressure bond between parts of Fe-Ni-Co by means of indium with adhering layers of gold. A pressure bond between parts of Fe-Ni-Co may be used, in which the sealing material consists of indium and the adhering layers consist of copper or silver. In the case of parts of Fe-Ni-Co the sealing material may consist of indium, tin, lead or an alloy, such as tin-lead, indium-tin or indium-bismuth. Parts consisting of a metal different from Fe-Ni-Co may be used and in that case the nature of the adhering layer is adapted to that of the metals forming the said parts and the sealing material. In all cases, comparatively elementary mechanical means may be used and the pressure force is always low and in the order of magnitude of a small fraction of a kg per mm length of the joint.

The invention may relate to the sealing of an electron tube of which one of the parts to be connected together is a window of a special material, for example silicon oxide glass, quartz, aluminium oxide, corundum or magnesium fluoride (MgF_2), calcium fluoride (CaF_2) or lithium fluoride (LiF). It is known that it is difficult to provide a metal ring within such a window in particular by a moulding method. This problem may be solved in the manner to be described hereinafter with reference to Figure 2. This Figure again shows the window 12 and the tube body 11 of Figure 1 but now the window consists of one of the above-mentioned materials for instance MgF_2. The mutual positions of the window 12 and the tube body 11 are inversed, the window being situated below the tube body. The metal cylinder 15, for example of Fe-Ni-Co, is inserted in the glass tube body 11 and has an end portion 16 which after a suitable surface treatment is coated with a layer of gold 25. (It will be obvious that this embodiment may also be used in the case of a window consisting of glass for industrial purposes.) A peripheral indium layer 23 is deposited on the window 12. Adhering layers 24 the natures of which depend on the material of the window are previously provided on peripheral surface of the window. These layers may consist successively of NiCr, Ni and Au or Cu or Ag in the case of glass for industrial purposes, silicon glass, quartz, aluminium oxide and corumdum, whereas in the case of a window of MgF_2, CaF_2 or LiF these layers are preceded by a layer of Ta_2O_5. The stages of the sealing of the tube are equal to the stages B, C, D, E shown in Figure 1, the sealing being effected by pressure exerted on the tube body 11.

It is to be noted that in all the embodiments described the cross-section of the metal cylindrical part having the narrow surface need not necessarily be circular and that the invention, due to its simplicity, can equally be used in any other shape, for example, an elliptical or polygonal shape of the metal cylindrical part 15. This is not the case in the prior art in which the sealing by cold pressing usually takes place in that one of the parts to be sealed together performs a rotary movement with respect to the other part to improve the tightness of the pressure bond. In this case a circular shape of the metal pieces to be sealed is necessary.

CLAIMS

1. An electron tube having an envelope composed of at least two parts, which parts have facing bonding

surfaces bonded together hermetically by means of a pressure seal consisting of a cold deformable metal, and in which at least one of the bonding surfaces is formed by an end face of a hollow-cylindrical metal body connected to one of the envelope portions, characterized in that the bonding surface formed by the said end face on its circumference has a width of at most 0.4 mm and the other bonding surface facing the end face is substantially flat and on its circumference has a width of more than 0.4 mm.

2. An electron tube as claimed in Claim 1, characterized in that the tube is a photoelectric tube and the envelope portions are formed by a window having a radiation-sensitive layer and a tubular envelope portion.

3. An electron tube as claimed in Claim 2, characterized in that both the window and the tubular envelope portion have a hollow-cylindrical metal body, facing end faces of the bodies being bonded together by means of a pressure seal, the body having the narrower bonding surface being provided in the window.

4. An electron tube as claimed in Claim 2, characterized in that the hollow-cylindrical metal body whose bonding surface has a width of at most 0.4 mm is provided in the tubular envelope portion and the facing bonding surface of the window consists of a layer of metal provided on the window.

5. An electron tube as claimed in any preceding Claim, characterized in that the hollow-cylindrical metal body whose bonding surface has a width of at most 0.4 mm is circular, elliptical or polygonal in cross-section.

6. An electron tube having an envelope composed of at least two parts, which two parts have facing bonding surfaces hermetically bonded together by means of a pressure seal, substantially as herein described with reference to Figure 1 or to Figure 2 of the drawing.

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